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Vol. I. No. 2.

JOURNAL

OF

THE ENGINEERING SOCIETY

OF

THE LEHIGH UNIVERSITY.

NOVEMBER, 1885.

ENGINEERING SOCIETY JOURNAL.

Subscription, Fifty Cents per year. Single Copies, Fifteen Cents.

[Entered at the Post Office at Bethlehem, Pa., for transmission through the mails at second-class rates.]

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DAILY TIMES PRINTING HOUSE,
BETHLEHEM, PA.

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THE WATER SUPPLY OF SOUTH BETHLEHEM.

It was not very many months ago that a prominent physician remarked that until a most decided change was made in the source whence the water supply of the Borough of South Bethlehem was obtained, the inhabitants might constantly expect an epidemic similar to the one which committed such dreadful ravages about four years ago. . Hitherto the Holly system has been in use, the water being obtained from the Lehigh River at a point immediately below the town, in the vicinity of the Bethlehem iron works. Not only was this supply totally inadequate to meet the demands in case of fire, but the liability to sewage contamination has caused many people to abstain entirely from using it as a drinking water. Until recently a large part of the supply was obtained from wells situated in the lower part of the town, but so intensely have these wells become polluted that their waters are now little better than the liquid matter in the cesspools which drain into them. Of late, however, the citizens have awakened to the extreme danger which they incur in using these waters, and as a result a contract has been awarded Messrs. Brown & Goodnow to furnish a good, adequate supply of wholesome water. It might be well just here to show the relations which the different waters in the immediate vicinity bear to each other, as determined by chemical analysis.

	No. of Samples	Total Solids. gr. per Gallon.	Chlorine. gr. per Gallon.	Free Ammonia. gr. per Gallon.	Albuminoid Ammonia. gr. per Gallon.	Nitric Acid. gr. per Gallon.
Lehigh water	3	8 2	0 21	0 007	0.103	0 00
Well water	10	27.2	3 75	0.040	0.083	trace.
Cistern water	2	4.4	0.13	0 000	0 009	0 00
South Mountain Springs	2	3 0	0 12	0.000	0 030	0 00
Bethlehem Springs	1	11.6	0.23	0 005	0.011	0.00

The samples of river water were obtained from a point immediately opposite Calypso Island, near the site of the new pumping station. The city of Allentown is situated about five miles up the river, but owing to the large number of shallows and small dams in the river, the water is thoroughly aerated, and nearly all sewage contamination has been removed; the free ammonia having changed into the albuminoid of ammonia, a perfectly harmless compound. The suspended solids are mostly lime, and tend to render the water palatable rather than otherwise.

On the Eastern brow of the hill, immediately back of St. Luke's Hospital, are situated two distributing reservoirs. These reservoirs are separated by means of a bank six feet wide in the clear on top, and have a slope of 2:1. The embankments are ten feet wide on top and have a slope of 2:1 on the inside and 1½:1 on the outside, with a total height of sixteen feet. The depth of the water in the reservoirs is twelve feet. Puddled clay to a depth of one foot has been used as a lining on the bottom and slopes, and overlying this is a covering of concrete one foot in depth, thus forming an impervious structure. The capacity of each reservoir is one million gallons, an amount wholly adequate to meet the wants of a population of ten thousand people for several days. The gate chamber contains six gates, and a stand pipe, the top of which is on a level with the surface of the water in the reservoirs when full, and acts as an overflow.

The boiler house is situated on the South bank of the Lehigh River, and between it and the L. V. R. R., immediately opposite Calypso Island. It is a compact stone building, thirty-eight feet in length by thirty-two feet in width. The front of the engine house wall is about six feet in thickness on the bottom, and rises to a height of twenty-five feet with a batter of 1:1 on the outside. The piers which support the engine are seven feet square, with the bed plates twenty-one feet above the suction pipe. The pump itself sets on the water. The river at this place is exceedingly

shallow, very rarely being more than one foot in depth. A Dickson compound pumping engine will be put into operation as soon as the works are entirely completed. The height of the reservoirs above the pumps is about two hundred and twenty feet, and the maximum head of water in the mains is about two hundred feet, causing a pressure of ninety lbs. per sq. in. The inlet pipe to the pump mains is twenty-four inches in diameter, the pump and delivery mains are sixteen inches in diameter; but the latter reduces to ten inches in South Bethlehem, and twelve inches in West Bethlehem. All mud pipes are six inches in diameter, and the reservoir drains empty into a sixteen inch tile. A grating is placed in the crib in order to arrest the entrance of the larger particles, fish, etc., and the openings of all pipes are covered with screens. The entire system is excellent, the most modern devices have been employed in the construction, and the greatest amount of care has been taken to make it as complete and effective a water supply as the circumstances would permit.

J. Hollis Wells, C. E.

THE HELIOTROPE AND ITS USES.

In this paper I will confine myself chiefly to the descriptive side of the subject, pointing out the origin of the heliotrope and its uses, as well as the method of using it in the field work of a triangulation.

In a primary triangulation, used as the foundation of an extensive survey, or for determining the length of an arc of the meridian, the sides of the triangles are of great length, often exceeding 25, sometimes even 35 miles, and in mountainous regions where the air is very clear, sides of a much greater length are used. As an instance of this kind we may name the great Davidson quadrilateral in the California triangulation. The sides of the triangles making up this quadrilateral are the longest ever measured anywhere, and vary from 54 to 194 miles in length.

On lines not longer than 15 miles the observations are usually made on what are termed signals. A signal as now used in the Pennsylvania triangulation consists of a straight pole of wood from

3 to 4 inches in diameter, and from 10 to 15 feet in length, on one side of which is fastened a frame work or any flat surface about 18 inches wide, upon which two pieces of muslin, the one black and the other white, are tacked. This signal is set exactly over the center of the station and faces the observer. It is necessary that the signal should be accurately centered and truly vertical. A deviation of .307 inch will make an error of one second in a line one mile long or 0.1 second in aline ten miles long.

That such a signal would be useless however on long lines, except under very favorable conditions of the atmosphere, must be apparent.

As long as the air is clear and free from mists, signals will do very well to observe upon; but let even a light haze obscure the view of the distant mountains, and signals become useless even at short range. It was this that in earlier times retarded the field work of a triangulation, forced the observer to use shorter lines, and thus increased the work.

When Schumacher and Gauss commenced their triangulation in Germany in the early part of this century, the heliotrope was unknown and signals only were used. The weather was unusually hazy when they were in the field, and the want of something that could be used to observe upon in such weather undoubtedly hastened the invention of the heliotrope.

In a letter to Schumacher, dated July 11, 1821, Gauss says: "——, I will gladly contribute to your new journal if circumstances allow. Perhaps a report on my new instrument, which I intend to call a heliotrope, might make the first paper. I hope that this manner of making observations may be made of the greatest importance for the higher geodesy. For short distances (up to two miles) you can imagine no better point to sight upon than the reflected light from a bright cloud; reflected sunlight will, I hope, make a most excellent point at the very greatest distances."

At what distances it actually is used at the present day would probably surpass Gauss' wildest expectations.

Gauss' heliotrope was however a clumsy and complicated instrument when compared with those now used. The form of heliotrope in use in this country is quite simple, consisting essentially of a board or telescope upon which are mounted in the same vertical plane as the axis two rings, and behind these a mir-

ror about 2 inches in diameter, having a motion about a vertical and a horizontal axis. The size of the mirror depends on the distance intended to flash over. Prof. Davidson of the U. S. Coast and Geodetic Survey, found that a mirror of 77½ square inches area sufficed, for his longest line, 192 miles. At that distance he saw, with a small telescope, a heliotrope light from a mirror 12 inches square.

It is only necessary to set the instrument by the rings on the telescope, upon the point at which it is desired to flash, and the reflected sunlight traveling parallel to the line of sight must strike the point.

To find the point upon which the heliotrope is to flash the heliotroper proceeds as follows: From his station he finds with his pocket compass, as nearly as possible, the direction of the observer's station. This direction has been determined roughly from the best available maps and a reconnaissance. After carefully centering his heliotrope over the station (the same care being necessary for centering here as in a signal,) he points it at the place where he supposes the observer's station to be. He allows his light to flash several degrees on either side of where he is pointing and keeps a sharp lookout for an answering flash from the observer, who is likewise flashing at the heliotroper. Sooner or later one sees the other's light and immediately points his heliotrope exactly. It is now an easy matter for the heliotroper to get a good pointing, and to keep it, provided his instrument is in good adjustment; if it is not, his troubles have just commenced, for he may then have to point his instrument in a dozen different directions before he finds one which satisfies the observer. When he has secured such a pointing, the observer signals him by means of flashes that his light is good. After this the heliotroper has only to keep his mirror turned so that the reflected sunlight may travel in the proper direction: an intensely interesting and above all a highly intellectual occupation.

It is hardly necessary to point out the advantages of the heliotrope over signals. The long lines above mentioned would of course never have been measured without it. To be sure it can not be used in cloudy weather nor at all hours of the day. Towards noon, and for several hours following, the light is very large, pale and blurred, and it has besides this a very strong vibratory motion. At times indeed the disturbing influences of the air are so great, that no trace of the light can be found, even when

its direction is accurately known. As the afternoon advances the light becomes smaller and more steady, and during the hours immediately preceding sunset it is seen as a small, often perfectly quiet point. Indeed the very best time for observing on a heliotrope is from six to seven P. M. on a clear still evening. Work done at such times may be relied upon, while work done during noon hours is never so reliable, whether the observations were made upon a signal or a heliotrope.

Another use of the heliotrope, though rather a secondary one, is that of a telegraph. It will be readily seen how the Morse alphabet can be represented by long and short flashes of light, and how a message may be sent by this means. The principal objection to this method of correspondence is perhaps the difficulty of attracting the attention of the person with whom it is desired to communicate.

JOHN S. SIEBERT.

SOME CALCULATIONS FOR A FLYING MACHINE.

The object of these calculations is to show, approximately, how far the muscular power of a man will go toward raising himself and machine in the air and overcoming the friction; I will therefore leave balloons and machines moved by power out of consideration.

We know that the power of a man is sufficient to raise himself at a moderate speed, and that it is possible to construct surfaces large enough to sustain his weight in the air, but the difficulty lies in the fact that he must not only raise himself but also the machine, and besides this must overcome the friction of the air and parts of the machine.

The first problem is to decide on the mechanical means best adapted to our end. Our first instinct is to imitate nature, and to copy as nearly as may be the flight of birds. But nature is no economist either in power or material, and her methods of construction are vastly different from ours. Success of locomotion on land or water has not been obtained by imitating the legs of an animal or the tail of a fish; but by various modifications of the wheel, a device nowhere found in nature. Another favorite device

is a large inclined plane moved horizontally by means of a fan revolving on a horizontal axis. But this would necessitate a continuous and rapid horizontal motion so that any regulation of speed would be impossible, and there would be great difficulty in starting and stopping the machine.

I have therefore chosen the fan or screw propeller on which to base my calculations. The speed forward could be regulated at will, and the machine could be raised and lowered perpendicularly. Two fans running in opposite directions must be employed in order that the rotative resistance of one may counteract that of the other. The fans are placed concentrically one above the other, but far enough apart that the eddies from the upper fan would not disturb the lower one. If the fans were placed side by side they would take up too much room and would necessitate a heavy frame.

The shaft of the upper fan passes through the hollow shaft of the lower one. On the end of each shaft is secured a bevel-wheel which gears with another bevel-wheel. On the shaft with the latter is a chain-wheel from which a chain passes down, over small guide pulleys in front of and behind the rider, to a chain-wheel beneath him. This latter wheel is turned by foot cranks similar to those on a bicycle. This arrangement is necessary to place the centre of gravity of the rider under the centre of the fans. A light steel tube carries at its upper end the bearings for the fan shafts, and the upper chain-wheel and bevel-wheel. The tube passes down back of the rider to the lower chain-wheel and cranks, and is secured to a tripod for resting on the ground. The rider sits on a saddle sliding on a horizontal arm projecting from the main tube. Behind the rider is a vertical sail or rudder moved by suitable handles.

The fan shafts are steel tubes and to the top of each are secured four horizontal tapering tubes to form the blades. Across these are secured light ribs of wood, and oiled silk is stretched over them. The blades are braced by steel wires extending to the lower ends of the shafts. The blades are long and narrow, which shape is chosen to prevent, as much as possible, the eddies of one blade from interfering with the one behind it, and also because experience in windmills has shown that a long and narrow blade has more effect than a short and broad one with the same area and inclination and moving at the same rate.

Forward motion is obtained by moving the body forward, thus

inclining the fans, which then act as inclined planes and tend to slide down and forward; but the motion of the fans would keep the machine at a constant height.

The machine would not, I think, weigh over 100 or 125 lbs. I base this estimate chiefly on the weight of the best makes of racing bicycles, and I will suppose that the same care is taken in the construction of the machine as in the bicycle. A racing bicycle has been made capable of bearing the stress put upon it by a strong man weighing 160 lbs., that only weighed 18 lbs., and a common weight is 22 or 23 lbs.

Now that we have the machine, let us find the proper size for the fans, and the power required to run it. I was unable to find any data relating to the thrust of a screw fan when revolved in the air, except for very small models, which would not apply to the large fans required for this machine. I therefore used an empirical formula giving the pressure which the wind exerts on an inclined surface as the basis of my calculations, assuming that the same effect is produced by moving the fans through the air. The formula as given by DuBois is: $P_n = P \sin i^{1.84 \cos i - 1}$. P_n is the normal pressure; P the pressure of the wind with a given velocity on a surface perpendicular to its direction; and i the angle which the surface makes with the direction of the wind. Another formula gives $P = (\frac{v}{20})^2$. v = velocity in feet per sec. Combining these we have $P_n = \frac{v^2}{400} \sin i^{1.84 \cos i - 1}$ $\therefore v = \frac{400 \times P_n}{\sin i^{1.84 \cos i - 1}}$. I first assumed the dimensions and angles of the fans, and found the velocity at which they must be run, and the power required. With a given area of fans and a given load to sustain, we can find the normal pressure P_n per square foot required; assuming that, since the blades are inclined but little, the total normal pressure = the total weight = W. I first assumed a blade 15 feet long and 3 feet wide at a distance of 5 feet from the inner end, and 6 feet wide at the tip; which gives an area of 52 square feet for each blade, or 416 for the 8 blades. I assumed W = 250 lbs. and hence $P_n = \frac{250}{416} = .6$ lbs. I also assumed that $i = 5°$ = average angle of the blade with the plane of rotation. We then have $(\sin 5°)^{1.84 \cos 5° - 1} = .131$ and $v^2 = \frac{400 \times .6}{.131} = 1838$, $v = 42.9$ feet per sec. = 3,574 feet, or 41 revolutions per min. If we assume a velocity of 120 revolutions per min. for the foot cranks, which is the speed

of a 56 inch bicycle wheel making the mile in three minutes, we have a velocity ratio of $\frac{120}{41} = 3$ between cranks and fans. Now the force required to drive these fans will be W sin i. W sin 5° = 250 × .08715 = 22 lbs. Hence the power required = 22 × 2,574 = 56,628 ft. lbs. per min. = 1.7 horse power. The pitch of the fans would be 5½ feet; but, since the calculations are based on the assumption that the blades go through the air at an angle equal to that formed with the plane of rotation, the slip is 100 per cent.; that is, the machine would be sustained at a constant height, but would not rise with the above velocity of rotation. The power required to give a forward motion will be considered later. With the same fans and $i = 10°$, we have $\sin 10° \, {}^{1.84 \cos 10° - 1} = .241$, $v^2 = 1{,}000$, $v = 31.6$ feet per sec. = 1897 feet per min. The force required is 250 × sin 10° = 250 × .17365 = 434 lbs. The power required is 1897 × 43.4 = 79,330 foot lbs. per min. = 2.4 horse power, or more than ⅓ greater than with only 5° inclination; so that evidently we must go the other way, and I find that with this size of blades and $i = 3°$, only 1.28 horse power is needed. As it would be difficult to make the blades perfectly flat, a smaller angle than 3° could hardly be used, and perhaps not less than 5°. Besides this, the increased velocity necessitated by a smaller angle would greatly increase the friction of the fans in the air.

An increase in the area of the blades decreases the power required as is seen from the following. With a blade 25 feet long having an area of 110 square feet, a total area = 880 square feet, and allowing 10 lbs. more weight, only .93 horse power is required to sustain the machine, the blades being inclined 3°. As it would hardly be practicable to make the blades over 25 feet long or fans 50 feet in diameter, it is not worth while to consider larger ones. We now see that, even under the most favorable conditions and assumptions, a horse power would be required.

We will next see how far the muscular power of a man, in good health and training, will go toward supplying this power. Here again I will have recourse to the bicycle. I do this because the power would be applied to the flying machine in the same manner, and besides this, I think a more accurate estimate of the actual power of a man can be had in this manner than in any other. Another way of estimating a man's power is by noting the time it takes him to run up stairs a certain height. From this we can

get the velocity of ascent per minute, which multiplied by his weight will give the work done in foot pounds per minute. In this way it was found that an average man can exert about ½ horse power for one minute.

With a bicycle, the power exerted is expended in two ways; in overcoming, 1st, the resistance of the air, and, 2d, the friction of the machine on the road and in its bearings. A small amount of power is also expended in keeping the machine balanced, but this diminishes as the skill of the rider increases.

The area exposed to the wind by the rider and machine is about 5 sq. ft. In making 20 miles within the hour, the pressure per sq ft. exerted by the air is about 2 lbs., so that a constant resistance of 10 lbs. is offered to the motion of the rider. This is overcome through $5280 \div 3 = 1{,}760$ feet per minute or 17,600 ft. lbs. per minute. Now we must allow about 10 per cent. of total power expended for friction, which is a low estimate. This gives a total of 19,550 ft. lbs., or about .6 horse power. But since the average horse can exert only about ¾ of a "horse power," for any length of time, we see that the rider is almost literally "as strong as a horse." In making a mile in 2 min. $31\frac{2}{5}$ sec., as has been done recently, the result is still more astonishing, for by a similar calculation we find the power exerted is 35,343 ft. lbs. or over one horse power. Mr. Hendee is credited by his English rival, Mr. Furnival, with making a quarter of a mile in 32 sec. At this speed the power exerted was at the rate of about 1.82 horse power.

From this we see that only a trained athlete could sustain himself at all, and he only for a few minutes. Then, too, I have considered only the power necessary to sustain the machine in still air, without forward motion. But in order to remain at some height, and yet move forward by inclining the fans, he would need an extra amount of force, equal to the upward force multiplied by the sine of the angle of inclination; and this force would also be equal to that required to overcome the resistance of the air due to the forward motion, which as we have seen above is considerable.

Thus we reach the conclusion that it is practically impossible to fly by muscular power alone. Whether it can be done with the aid of steam, compressed air or other similar motors, is a question which is at present occupying the attention of many scientific and practical men, and the result of their labors is looked forward to with a great deal of interest. CURTIS H. VEEDER.

FREEZING METHOD FOR EXCAVATING.

One of the ordinary methods of securing a safe foundation in locations where troublesome water-bearing materials are of great depth, is the pneumatic process. By this process the use of compressed air is necessitated for the purpose of sinking the timber and iron caissons, and also to supply the workmen with fresh air. But the use of compressed air is limited to depths not exceeding 100 feet, for beyond that depth the air pressure exceeds the limit of human endurance.

At the Havre de Grace Bridge, the greatest depth reached was 90 feet below high tide; there were three or four deaths and three or four cases of permanent paralysis, the greatest temperature in the working chamber being 106° F. Among the many advantages of the process is its absolute certainty; it can be used whatever material overlies the ultimate foundation. Satisfactory results are obtained, and it also gives the engineer an opportunity to examine the foundation, and if necessary, to level the foundation to any desired degree, so that when the masonry is commenced on this surface, it can be considered of undoubted stability. Deep foundations can in some degree be done away with by using suspension or cantilever bridges.

The freezing process invented by a German, Mr. F. H. Poetsch, will without doubt overcome all these difficulties. The object of the process is to convert the material to be excavated, whether quicksand or water-bearing earth, into a solid mass, or rather to surround that part to be excavated with a solid wall of ice, which prevents the water from getting into the shaft. It will be seen that by the use of this process pumping machinery and timbering will not be necessary. The material is converted into a solid mass by circulating a very cold solution through a system of pipes sunk into the sand or water, as the case may be.

The first piece of work done by this process was in the Archibald Lignite Mine, near Schmeidlingen, Germany. A shaft 15 × 10 feet had been sunk to a depth of 107 feet through rock, but was separated from the bed of lignite by a layer of quicksand 18 feet in depth. Here Mr. Poetsch sank 23 pipes, 10 of them along the walls of the shaft through the quicksand and 13 feet into the water under it, the diameter of the pipes being 8 inches. The lower ends of these pipes had an inner conical attachment against

which a wooden plug was driven from above, thus closing the pipes below. After emptying the pipes with a sand pump the bottom was plugged with layers of cement, gypsum, and loam, each 2.3 inches in depth. Into every freezing pipe, a pipe 1.2 inches in diameter, open at the lower end, was introduced. The freezing solution entered the latter pipe from above, and descending flowed out of its lower end, up in the circular space between the two pipes. A constant circulation was kept up through the ice machine, which was of the Carré type. The freezing solution was chloride of calcium, which freezes at —40° C.

For the purpose of measuring the temperatures from time to time, twenty 1.5 foot pipes were inserted in the walls and bottom of the shaft. The work was commenced on July 8, 1883, and from the following table the changes of temperature can be seen:

	Bottom.		Sides.		
July 8.....	12° C	11°	11°	11°	11°
July 15.....	—1.5°	— 6°	—4.5°	— 5°	—7.5°
July 23.....	— 4°	—14°	—17°	—14°	—13°
July 31.....	— 6°	—19°	—17.5°	—19°	—18°

When the work was finished it was found that the lignite had frozen to a depth of over 3 feet, and it was also found that there was a column of ice 4.9 ft. in diameter around every freezing pipe.

Another piece of work done was at the Emilia shaft. The shaft was 8½ feet in diameter and was sunk through 115 feet of water-bearing sand formation. In this case 12 circulating tubes were used. From 12 to 15 days were required to sink these tubes a depth of 100 feet. The circulation of the liquid through these tubes was made by a small pump with a piston 6 inches in diameter and 12 inches stroke. At the beginning of the operation this pump made 30 double strokes per minute, which was equivalent to the passage of 0.6 gallons of the liquid through each tube per minute. At the end of the operation the pump only made 15 strokes per minute. The quantity of ammoniacal liquid necessary to charge the apparatus was 281 gallons, the average daily consumption being 0.78 gallons.

The excavation was commenced 53 days after the freezing apparatus had been set in motion.

The workmen were paid $14.40 for every metre (3.28 ft.) of sinking. When the excavation was completed they circulated a hot solution through the pipes, for the purpose of thawing them

loose from the surrounding ice and the tubes were then easily extracted. Below is a very close estimate of the actual cost of the work done. The work on the above mentioned shaft was commenced on July 1, 1884, and was finished March 1, 1885. The ice machine was in operation 240 days.

Use of apparatus	$4,700
Cost of moving machinery and apparatus	1,250
Setting up and fitting pipes, &c	6,000
Service of ice machine 240 days @ $15	3,600
Excavation and lining 115 feet @ $21 per foot	2,415
Engineering and incidentals	2,035
Total	$20,000

From this we see that the cost per linear foot was $173.91.

When we wish to use this process in the construction of foundations under water, two methods are at our disposal. One is the combination of the pneumatic caisson and this process. The pneumatic caisson is sunk to the bottom of the river, and then from this bottom the freezing pipes are driven around the material to be excavated. The air in the working chamber is supplied to the workmen in the usual way. The other method is to insert the freezing pipes directly into the water, and after the ice is taken away, to insert the pipes into the river bed to such a depth as is necessary to reach a good foundation.

As the masonry in the foundation is constructed when the surrounding temperature is very low, the mortar or cement would do no service as a binding material, for the water in the cement would immediately freeze. In order to protect the masonry against the low temperature, the outer surface of the walls of the shaft is covered with straw or slag-wool; or a mixture of tar, pitch and sand is used as a cementing material. Instead of using water in the cementing mixture, a chloride of magnesium solution may be employed, as this solution freezes at —40° C.

It will be seen that this method is particularly applicable to excavation in quicksands in the construction of docks.

From the work done at different localities, it is proved that this method is perfectly practical, and that it can be applied to any depth and also to any kind of material.

It is valuable inasmuch as the engineer can make an accurate estimate of the total cost before the work is commenced; and, secondly, that the engineer is always sure of success.

The method is already in extensive use in Germany, and it is to

be applied in the construction of a railway tunnel near Lyons, France.

By its efficient and economical way of executing work, it may be classed as one of the powers of the engineering world and much can be expected of it. L. J. H. GROSSART.

THE QUARRYING AND MANUFACTURE OF SLATE.

The important industry of slate quarrying is apparently in its youth, as illustrated by the fact that there has been only one book published on this subject, while many volumes have been written on industries of less importance. This book is a small volume by Mr. D. C. Davies, E. M., and treats principally of the slate quarries of Wales, merely mentioning those of our own country.

Slate is stone which possesses a highly laminated character and is capable of being split into thin plates. There are two classess—clay slate and tile stones. The former is the principal kind, and nearly all of our slate is of this class. They are metamorphic rocks, found among the oldest of geological strata, and are the densest of stratified sedimentary rocks.

Mr. Davies gives the following as the method of formation: "There was first of all an immense quantity of mud, washed by rains of the old lands and carried by rivers to the seas. This mud was made up, for the most part, of silica and feldspar with smaller amounts of lime, magnesia, iron, potash, copper and carbon. When brought to the sea, the mud was deposited in layers or beds in which the remains of creatures belonging to the sea became imbedded. The mud in course of time became covered with other materials, the whole mass slowly hardening and consolidating by pressure as well as by heat. Lifted out of the water it cracked and split in various directions in the process of drying."

"Influenced by that law of crystallization by which all minerals assume certain definite shapes, silica and feldspar forming the bulk of the deposit, the mass split up for the most part into rough rhomboidal masses. This crystallization and splitting up was aided during long ages by magnetic currents which passed through the mass to the N. N. E. and which gave a tendency in the particles to arrange themselves in that direction. Then there came

great disturbing forces by which the beds were bent and twisted in all directions. The great pressure attendant on these lay between N. N. W. and E. S. E., and between these two points the particles of the mass became flattened and compressed into about half of their original bulk, and thus imparted to the unbroken masses of rock that lay between the great cracks and divisional planes that tendency to peel off from each other which we now know as slaty cleavage."

Slate occurs in beds, not veins. When it contains flakes of mica, it is known as mica slate, when talc, as talcose slate, and when hornblende, as hornblende slate; none of these kinds have the commercial importance of clay slate, from which common variety all the roofing slates of commerce are derived.

One cu. ft. of slate weighs about 180 lbs., or it is a little heavier than common stone, which weighs about 160 lbs. per cu. ft. Its power of resisting pressure is very great, requiring 20,000 lbs. to crush one cu. in. Hence we see that although its density is but little greater than that of stone, its compressive strength is over three times as great. It is also very tenacious. The average composition is silica 60, alumina 20, protoxide of iron 7, the remainder being made made up of magnesia, potash, and water. Thus it is seen that these deposits are made up chiefly of silica and alumina, and were at one time ordinary clay.

The color of roofing slate has a great deal to do with its value, and it is very desirable to have a slate that will hold its color; the most common color is blue, of different shades, which is due to the protoxide of iron present. Dark blue, a blue-black as it is called, is the best slate; the highly colored slates do not hold their color, and besides they are generally expensive.

The chief slate producing countries of the world are Wales and the United States. Slate is also found in smaller quantities in England, Ireland, France, and Sweden.

But the quarries of our own country interest us more than those of Europe; the largest being at Monson, Me., in Vermont, and in the Slatington, Bangor and Peach Bottom regions of Pennsylvania. Before the quarries in America were fully opened, large quanties of Welsh slate were imported, but since the development of the American quarries, scarcely any Welsh slates are imported, and there is a large foreign demand for the American product.

The quarries of Monson, near Bangor, Me., were opened in 1870; the beds are 250 feet wide and over a mile long. The roof-

ing slate has the reputation of being the strongest in the world; it is very elastic, and of an unfading blue-black color. It splits only in one direction and has none of the curvature which characterizes most slates. It is near the surface, and is easy to quarry, as it splits easily and is very regular. The Welshmen are the best slate workers in the world, hence large numbers of these were brought over to this country to work in these quarries.

The Chapmansville quarry in the Bangor region, Northampton Co., Pa., was first opened in 1850. In this region are located the quarries of the Chapman and New York Slate Manufacturing Co., the Fischer Slate Co., and the Edelman quarry. They are owned mostly by New York capitalists.

The quarry of the Chapman Co. is an excavation 1,000 feet long, 300 feet wide and 225 feet deep. It is called a flat rock quarry, the split of the slate inclining to the South at an angle of 10°.

The Peach Bottom district is situated in York and Lancaster counties, Pa., and there are a number of quarries near West Bangor, on the right bank of the Susquehanna. There are eight quarries in this section and the slate is softer than that of the other quarries in Pennsylvania.

An old quarry in Lancaster County called Brown's quarry, has been worked over a hundred years; it is getting too deep for practical working.

The Slatington region is the best in Pennsylvania, and there are a large number of quarries there. Mr. Henry Kuntz, of the Slatington Slate Co., has had a large experience in this industry, and has opened a large number of quarries, the majority of which have been abandoned.

The principal beds are the Washington and the Franklin, the latter being about two or three miles from the town of Slatington; it is the largest quarry in this section, and the vein or bed is shaped somewhat like a basin. The Washington bed is very deep, and there are two layers with a layer of flinty rock between. The thicker layer of slate is 30 feet deep, the other 20 feet, and the layer of flint 14 feet.

After working down about 250 feet in the Franklin quarry, the vein of slate alone was followed, leaving the flinty rock in place. At intervals of about 100 feet a pillar of rock was left standing to support the roof. This quarry produces a very fine quality of blue black slate; it is very hard, durable, and keeps its color.

Most of the slates from these quarries are shipped West, large

quantities going to Chicago and the larger towns of Ohio and Indiana.

The quarries at Slatington are owned principally by private parties, while in the Bangor region they are mostly owned by stock companies.

It is a strange coincidence that four of the largest slate markets in the world should have the same name, they being Bangor, Wales; Bangor, Me.; Bangor, Northampton Co., Pa.; and West Bangor in the Peach Bottom district.

The method of manufacturing the slate is as follows: The workman first blasts the large masses of slate in the quarry, and puts them on a wooden box, one end being open to facilitate loading. These are hoisted by a derrick to the surface, where they are loaded on trucks and moved along a track to the shanties where they are split. A small engine at the surface furnishes the power to raise the slate from the bottom of the pit.

The splitter with his mallet and broad steel chisel sits on a block, and, taking a slab of slate between his legs, drives in the chisel a little at one end. He moves it a little with a firm, gentle pressure, and you can see the split begin to start "as straight as a die." He repeats the operation at the other end, and then drives his chisel in the middle, and easily pries the slab in halves. These pieces are split, and split again until they are of the required thickness, when the dresser takes them. He cuts them by means of a large steel knife, which works much like an old fashioned cutting-box knife, to the largest size they will conveniently make. A gauge board guides his eye, and he puts his slate against it, pressing his foot on the treadle, and down comes the knife cutting the edge clean and straight. One would think that these knives would soon wear out, but on an average they last from six months to a year. The slate, after being brought from the quarry, must be kept continually moist until it is split, for if it dries out it cannot be split at all.

In manufacturing blackboards, hearth stones, &c., the rough slate is brought from the quarry and sawed to the required size with circular saws. These are about ¼″ thick and revolve very slowly on account of the great amount of heat generated by the friction. After sawing some are planed, but generally they are put on a cast iron wheel or disc, about 10 feet in diameter, revolving horizontally. On this is put fine sand mixed with water, and this mixture is kept running on continually. On the disc are put

two large pieces of slate at a time, heavy weights being put on to keep them down and increase the friction. In ½ to 1 hour they are taken off comparatively smooth, and are then rubbed with pieces of grit until perfectly so, after which they are boxed ready for shipment.

The size of roofing slates range from 6×10 inches to 14×24 inches, including about 34 different sizes.

Roofing slates are sold by the square, a square being 100 sq. ft. The number of slates of the size 14×24 inches in one square is 98, and of 6×12 inches is 533. The *Scientific American* in 1881 said: "Ten years ago the roofing slate industry of this country was not considered of sufficient importance to receive a bare mention among the 'special industries' of the census report. Last year the capital invested in this industry was $8,000,000. Over 3,000 men were employed, producing 600,000 squares, or enough to cover 60,000,000 sq. ft." E. S. STACKHOUSE.

THE PRESERVATION OF THE OBELISK IN CENTRAL PARK.

Cleopatra's Needle in Central Park is rapidly disintegrating under the influence of the cold and damp atmosphere of our climate, so that in a few years it will be utterly destroyed unless steps are taken to prevent further destruction. Paraffine is one of the best known substances for this purpose, but there would be great danger of cracking the stone by the heat necessary to melt the paraffine if it is heated, as is proposed, by charcoal fires.

But this danger might be avoided and the stone safely and evenly heated by the use of steam passed through a coil of iron pipe surrounding the stone. The coil could be formed of short, straight pieces of 1 or 1¼ inch pipe, screwed into elbows at the corners of the stone.

A coating of melted paraffine should first be applied to the stone with a brush, and then the coil built up from the bottom, leaving a space of say 8 or 10 inches between each coil of pipe. The coil should then be covered with a casing of sheet iron, either riveted or soldered with hard solder. Then steam should be passed through the pipes from the top, and melted paraffine

poured into the space between the casing and the stone, until it is completely filled. The steam should be supplied at first at a low pressure, and afterwards, as the stone becomes heated, the pressure should be increased until the whole mass is raised to the temperature of the steam. The melted paraffine would communicate the heat from the pipes to the stone gradually and without danger of cracking or chipping; and by keeping up the heat for a time the stone would be thoroughly soaked. The melted paraffine would then be drawn out at the bottom, and the stone should then be allowed to cool slowly for several days. Any superfluous paraffine could then be removed with alcohol or ether. The steam could be supplied from a small and strong portable boiler, and the condensed steam returned to the boiler from the bottom of the coil. The casing should be covered with wood or felt to prevent loss of heat, and, in addition, be braced or strengthened at the bottom, to prevent bulging or bursting under the pressure of the liquid paraffine. The casing should of course be made tight to prevent leakage. If it is desirable to save the expense of so much paraffine or pipe, part of the stone could be treated at a time, beginning at the top; but it would be preferable to heat the whole stone uniformly at the same time. Or, paraffine might be saved by placing the casing close to the stone, keeping it away from the latter by small pieces of wood, and then coiling the pipe around the casing; the escape of heat being prevented by a thick coating of felt. Other modifications of the process may suggest themselves, the idea being to gradually heat the stone by steam to avoid cracking, and to maintain the heat long enough to allow the paraffine to thoroughly penetrate the stone.

CURTIS H. VEEDER.

A BROKEN WATER MAIN.

About five o'clock in the morning of Sept. 24 last, water was seen rushing from a break about 2 × 3 feet in the side of the large 36-inch water main near Green Garden, District of Columbia. The water poured out in such quantities and with such a velocity, that in a short time it cut a gully through the soil and soft rock,

several feet wide and from seven to eight deep; then spread itself over the canal road, and finally flowed into the canal.

As soon as it was discovered, word was sent to the proper authorities, who tried to turn the water off from the broken main and use only the thirty and ten inch mains which run along side of the broken one. The valves, which ought to be kept in order for just such occasions, would not work, and the water had to be cut off from all the mains. Word was telegraphed to New York early in the day for a sleeve with which to repair the break; but as it could not be sent in time it was determined to put on a permanent patch. A sheet of boiler iron 4×4 feet and ½ inch thick was bent to the proper curve. Three sheets of lead were first placed over the break, then the boiler iron, all of which were pressed tightly against the pipe by means of four wide iron bands ½ inch thick, drawn together at the top and bottom of the pipe by bolts. Lead was then poured all around the patch and caulkers soon finished the job.

It was lucky that where the break occurred the terrane is such that the escaping water instead of following the line of pipes was turned off at a right angle, for, if it had followed the pipes and washed the soil from under them, they might have broken under their own weight, and occasioned a more serious accident.

The piece of pipe which gave way was anxiously sought for, in order to determine the cause of the accident; but up to the present time it has not been found, and so the cause remains a mystery.

F. F.

The large sewer which is building along Boundary street, Washington, D. C., has a width of 15 feet at the springing line, and is 17.5 feet deep. The section is a combination of the circle and the ellipse, the lower part being a semi-circle with a 7.5 foot radius, while the upper part is a semi-ellipse with the 10 foot semi-major axis vertical.

In building the sewer the lower portion of the sides and the bottom of the cut are dug to the slope of the sewer. Then a foundation of concrete is spread, upon which comes one depth of trap rock; one thickness of brick is then laid around the section, and the upper part and sides of the shell built of the required thick-

ness by spreading Portland cement over the bricks to the depth of about one foot.

Calculations were first made for a circular sewer, but afterwards it was decided to use the shape stated above. The deepest cut along the line of sewer is about fifty-five feet.

A COINCIDENCE.

[The following article, together with the foot-note by the editor of the *Engineering and Mining Journal*, illustrates how two or more men, without any communication with each other, make the same discoveries and inventions. Mr. Clerc's letter, written to the editor of the *Engineering and Mining Journal*, was for some reason not published in that paper, and, thinking it may be interesting to our readers, we give it below.—EDS.]

To the Editor of the Engineering and Mining Journal:

DEAR SIR:—The recent accident to the "City of Berlin," caused by her running into an iceberg in a fog, suggested to me an idea which I have been turning over for several days. The idea is a device for determining the direction and distance away of a neighboring iceberg, in the dark or in the thickest of fog. The device is so simple, and so apparently obvious, that I hesitate to speak of it as new, even to myself, but as I do not know of its being in use anywhere, or having ever been tried, and have never heard it referred to as an exploded theory, I will give you an outline of it and submit the arguments in its favor, trusting that, if you do not judge it outlawed or condemned on its own showing, you will submit it to the jury of your readers with an impartial charge.

All accounts which I have seen of icebergs met with in the track of European steamers, describe them as projecting to a considerable height above the water, and it seems probable that only their immense bulk enables them to reach these lower latitudes, and that after they have shrunk so as to be nearly level with the water, their further breaking up is very rapid. Such a mountain of ice, though taciturn, would, I think, answer if properly addressed, and tell, if attention were given to its answers, anyone how to keep out of its way. The intensity and interval of an echo from a sound produced on ship-board, ought to be a very correct measure of the position and distance away of the reflecting surface.

The sound of course should be one that can be easily recognized, and short enough to give a distinct echo, even at short distances. Experiments with fog horns and syrens have been numerous enough to determine what class of sounds have the greatest penetrating power. Such a sound should be produced, and its waves should be projected ahead of the ship by a parabolic reflector rotating about a vertical axis, and its echo should be received and conveyed to the ear of the observer by a similar device. It would be well to shut out as far as possible all other noises coming from wind or wave, or ship,

by deadening partitions, of mineral wool or similar material. Imagine the following dialogue: time, midnight; dense cold fog indicates near presence of hungry iceberg; Captain goes to the telephone, and rings up Old Man of the Sea, in pilot-house of iceberg, with a sharp "Hello," that is, "where are you?"—one—two—back comes the answer, "Hello," in echo cypher, "1,100 feet away, on (say) the starboard quarter." A word to the pilot-house and engine room puts the ship on the port tack at half speed. Another challenge, dead ahead, "Hello, how's that for a close shave?" Silence. "That is once you got ahead of me." Full steam again, and a call across the bows, "You there! stay there"—one—two—three—answer very faint and out of breath, "1,700 feet away, but just let me catch you." And so on, *ad libitum*, as long as the impatient cabin passengers will allow the captain to run the boat the way he thinks best. Of course there would be but few occasions to use this aerial telephone which converses with solid walls, and possibly a sailor would object to providing against this not-to-be-thought-of predicament. But I think the plan worth a careful trial, and believe that a considerable degree of accuracy in the determination of direction and distance can be obtained with a little practice. I consider the reflector and insulators important, and think it desirable that the outlook should be able to regulate the intervals between the challenging cries. He could easily reckon the intervals and distances with sufficient accuracy by a mental count. Yours truly,

F. L. CLERC.

[This article was sent to me and received by me within a week after the accident to the City of Berlin. Several weeks later I saw Prof. Bell's experiments published in *Science*, and announced the fact to Mr. Clerc and he promptly asked me to purchase him a copy of that paper. The priority of invention is unquestionably with Mr. Clerc.—R. P. ROTHWELL, *Editor Eng. and Min. Journal.* N. Y. July 11, 1885.]

ALUMNI NOTES.

1874.

—C. W. Haines has gone to South America, and at latest advices was in the Argentine Republic.

1876.

—Walter P. Rice is one of the Committee of the Engineers' Club of Cleveland which has in charge the matter of organizing a movement to secure a better status for the civil engineers employed by the National Government.

1877.

—H. S. Jacoby is now with G. W. Jones & Co., 267 Main street, Memphis, Tenn.

1878.

—The letters "M. P. P., Ass't. Engr., 1885," are cut upon the keystone of a fine stone arch on the extension of the P. S. V. R. R., above Reading. This arch is the work of Milnor P. Paret, Assistant Engineer in charge of the construction of a section of that road, who now has his headquarters at Harrisburg, Pa.

1879.

—J. H. Paddock is the head of the firm of Paddock & Bowman, Engineers, Connellsville, Pa., who are engaged in railroad and mining work.

1880.

—The address of F. P. Spalding is Room No. 2, Cotton Exchange, Memphis, Tenn., where he has opened an office as Engineer and Contractor.

1882.

—Eugene Ricksecker, Topographer on the U. S. Geological Survey, covered nearly 9,000 square miles during the past season with secondary triangulation and plane table work. He returned to Washington about the first of December.

1883.

—J. de Bruyn Kops is at Chicago, Ill., engaged with the Chicago Telephone Company.

1884.

—The address of A. P. Smith is 13 Waverly Place, New York.

—J, F. Merkle is now on the engineer corps of the Lehigh Valley Coal Co., at Wilkes-Barre, Pa.

—H. T. Harper was employed during the Summer as a leveller on the L. V. R. R. corps at Hazleton, Pa.

—R. W. Walker was at Guatemala City in August, the field work of the boundary having been suspended during the rainy season.

1885.

—T. W. Birney is studying law.

—John Wagner is at Drifton, Pa., with Coxe Bros. & Co.

—The address of Felix Freyhold is 236 First street, S.E., Washington, D. C.

—Thomas Nicholson, Jr., '83, and D. K. Nicholson, '85, made an extensive trip through Europe last Summer.

—C. M. Tolman is working for the Armington & Sims Engine Co. His address is 38 Carpenter street, Providence, R. I.

—The address of F. B. Petersen, lately employed on the Washington Aqueduct Extension, is 111 C street, S.E., Washington, D. C.

—H. W. Rowley and J. H. Wells have made a map of Bethlehem, South Bethlehem and West Bethlehem, an edition of which will soon be published by E. G. Klosè, Manager, on a scale of one inch to 400 feet.

—W. N. Edson and E. O. Smith were at work for Prof. Merriman during the Summer on the geodetic triangulation of Pennsylvania. Edson has lately gone to Michigan, where he expects to engage in copper mining. Smith is on the L. V. R. R. corps.

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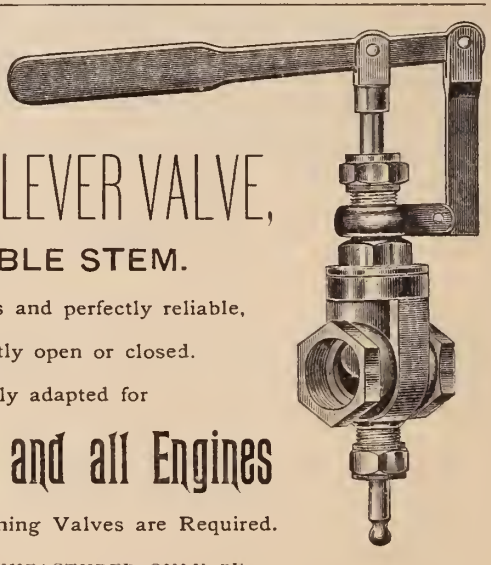

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